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Designing for Non-Humans

An Interview with Joyce Hwang

Ralph Ghoche

This interview took place remotely on November 12, 2021 between Ralph Ghoche, Assistant Professor of Architecture at Barnard College, and Joyce Hwang, Associate Professor and Director of Graduate Studies at the Department of Architecture, University at Buffalo. Hwang is a registered architect in New York State who develops constructed environments that incorporate wildlife habitats. Her projects include “Bat Tower,” “Bat Cloud,” “Habitat Wall,” “Bower.” Her latest project, “To Middle Species, With Love,” was installed as part of Exhibit Columbus, and is on display in Columbus, Indiana until the end of 2022. Past work can be viewed on Hwang’s website, *Ants of the Prairie*.

RG: Thank you for taking the time to talk with me about your work on animal habitats. I believe it will be as new to French audiences as some of the work in France may be to people in the US.

JH: There may be more theoretical thinking about these questions in the US, but in Europe, in places like the Netherlands, Germany or the UK, it seems like there’s already a lot of ongoing work. There are even building product manufacturers in Germany — such as Schwegler — that are making bricks for animals to live in. So, there’s a lot of work around in Europe. You know the Mellor Primary School by Sarah Wigglesworth in the UK has a kind of insect wall as part of it. There’s a very technical book that’s about integrating wildlife habitat into buildings (*Designing for Biodiversity: A technical guide for new and existing buildings*) that’s published by RIBA.

Figure 1. To Middle Species With Love



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RG: I wondered if you could talk a little about an expression that you often use, “architect as advocate.”

JH: Okay, sure. Well, I started using the phrase “architect as advocate” in thinking about some of my work when I realized that creating small scale projects that somehow drew awareness and brought interest to particular populations—whether it’s bats, bees or something else—was a way that architecture could bring attention to and empathy toward particular species. And so the idea of thinking about how architects can be activists in a sense, to address situations like bird-glass collision is a big issue. Nowadays, there is an increasing number of practitioners who are working on things like bird safe building guidelines—there’s even a LEED pilot credit for bird glass collision that’s out there. So you can work on policy and you can advocate through policy but, as an architect and a designer, there might be ways to bring more attention to something like bird glass collision as an issue. One is just advocating for issues that impact populations that are marginalized and not thought of. When I say marginalized, I’m also thinking of humans too, so it’s not just animals but how we can think of inclusion among humans in general. But in terms of thinking about non-human species, how to translate needs and so on, I don’t think we, as humans are necessarily able to translate directly. It’s not like we can talk to an animal and ask them questions in their own language, we can’t communicate with them specifically, but there are different ways that one can observe. There are practices of observation, there’s mapping. I usually do a lot of collaborative work talking with biologists and ecologists and trying to learn as much as possible. So, for example, in the most recent project that I did for an exhibit in Columbus [Indiana] called Exhibit Columbus—this is a minor example but it was also something that was totally visceral at the same

time—we were making the structures' bases by stacking stones and creating little gaps for small amphibious animals and small terrestrial animals. (Fig. 1) While we were building the project, we saw these toads trying to jump in but it was hard for them to reach because of the height of the foundations that we had made. So, through this observation we started stacking stones around the base to make it easier for the toads to jump in. After a period of time they started inhabiting the project, even while we were designing it. It may be a ridiculous thing to talk about but I think observation is the key if you're not necessarily an expert and you're not regularly observing and researching animals, which is something we as architects are not doing.

RG: The question of representation is an important one. I think about all the philosophical and legal work that's been done in terms of giving agency to the environment, the whole concept of ecocide, to put that in relation to say, laws that are universal laws that safeguard the rights of humans. Now, of course, there is talk of the universal rights of non-humans. So, I wondered at a larger scale of the architect as advocate, do you see the role as being more all encompassing in relation to, say, non-animal actors as well? So, for example, in dealing with climatic change, to what extent does the architect have a role to play in making visible these larger atmospheric phenomena.

JH: Yeah, I think what you're saying about making things visible and representation is spot-on in terms of advocacy — not only in terms of non-human species, but climate change, biodiversity loss, carbon, and any issue that needs attention through strategies of visualization, mapping, and representation. Making projects that somehow embody the sensibilities related to issues that are important — I think that's really something that architects should aspire to do. When I think about the idea of advocacy, it's not just about making visible but about being a detective as well. This goes back to observation; how can you look beyond what's already out on the table and think about what's being ignored? That could have something to do with nonhuman species, but it could have to do with other things too.

Figure 2. Penguin Pool



Wikimedia Commons, The Meat Case

RG: I have a couple of questions that relate to historical examples of architects designing for animals. The one example—and I'm sure you're very familiar with it — is Berthold Lubetkin's penguin pool at London Zoo. (Fig. 2) What's interesting about it — of course you've probably heard that it's no longer used for the purposes it was designed for...

JH: Oh, yeah, I'm not surprised. I did visit it in 2000 and watched it being used, and it didn't look too comfortable.

RG: What's interesting about that project is, yes it was adapted for penguins, but mostly, it's a spectacle for humans to gawk at these penguins parading down like it's the staircase of the Paris opera house. I wondered about your work in relation to the role of human vision onto these habitats.

JH: I think there is something to be said for spectacle and its ability to bring attention. This is the power of places like zoos. One could say that it's not a good idea to keep any animals in captivity or to force animals on a ramp or to keep birds in a cage, so I completely agree with that. But I think the idea of creating a spectacle visually is certainly something that is able to draw human attention. And oftentimes, probably most people who have grown up in a city or in suburbs, their first interaction with animals is probably in a zoo. I mean mine certainly was, aside from seeing wildlife in the backyard and birds, my first fascination with animals came from going to a zoo when I was a little kid, and I'm sure that is the same with many children. Even conservation biologists use the term charisma, non-human charisma, to talk about the ability of animals that look a certain way to attract more attention, to bring attention to conserving not only that species but also other species. How can you draw from the optics and visual appearance of an animal towards conservation efforts? So, I think humans as audiences are really important. But at the same time, in my work, I'm really interested in thinking about the human audience as key. Even though the clients, or the inhabitants or users are animals, it's really important that there is a way that the project also impacts or resonates with humans as well. In the

case of the Lubetkin penguin pool, from my understanding — and I'm not a historian — the distance of the pool relative to where the penguin entered the water, and the radius of the pool weren't conditions that allowed penguins to swim comfortably. When the penguins were swimming they'd have to turn in a way that was almost too soon and didn't accommodate their specific mobility preferences. In my work, paying attention to animals' preferences and tendencies is what I'm more interested in pursuing. Of course, you're familiar with the term *umwelt* by Jakob von Uexküll. I think it's really important to map out these conditions that are specific to animals and to use that information, rather than thinking of human constraints first and foremost. If you can't get a pool where penguins can swim comfortably, maybe you don't build a pool at all, and you do something else.

Figure 3. Biosphere 2 Campus



Wikimedia Commons, Katja Schulz

RG: Yeah, what happened with Lubetkin's project is interesting because he did consult with a biologist. He consulted with none other than the evolutionary biologist Julian Huxley. But despite his collaborations there were these unexpected misalignments. Architects like to talk about post-occupancy, there is a whole tradition about thinking about the way that architecture is used or misused—we can think of Bernard Tschumi—but dealing with non-humans it's particularly difficult because often we're talking about the very survival of a species. If there are misalignments, mistakes can be quite catastrophic. One can think about Biosphere 2, the closed ecological system research facility in the Arizona desert where scientists imagined they could replicate a very complex set of ecosystems. (Fig. 3) They quickly realized that, when you bring in too many variables, things get so complex that they become really hard to model, really hard to predict. So I guess I wondered about misalignments in your own work. What are some ways that your structures have been used against your intentions? Are there cases where species you hadn't considered ended up finding habitats in your work?

Figure 4. Bower 2



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JH: In a project I did for Artpark, we designed a project called Bower for seven different bird species. (Fig. 4) And I consulted with a biologist to get specific recommendations for these seven bird species and it had everything to do with which direction the nesting box faced, which way the hole was going to face, either north, south, east or west, and what sizes the holes would be. I went through these specifications pretty rigorously and maintained them throughout the design. But it turned out that the bird nesting box that had a larger opening was actually not used by the bird that was intended — a Purple Martin — but was used by some other bird species that was a problem. It might have been a starling but it was being used unintentionally because of the relatively large size of the hole. And so, we were asked to put wire mesh on the holes to exclude the species they didn't want. If you look at the project it looks like the bird boxes have openings but some of the boxes are actually closed off with wire mesh behind the holes. I think another unintended consequence happened in a project I co-directed as a faculty member where graduate students at University at Buffalo developed a design-build beehive installation. The project was essentially to move a living beehive that had formed organically behind a piece of plywood in a building that was going to be renovated. The building owner was going to give the beehive away. We, some faculty members in the architecture department, said, rather than asking a beekeeper to remove the beehive altogether, let's try to move the bees into an artificial beehive that students could design. We held a design competition for students. There were a number of different teams and four finalists. The students designed a beehive based on recommendations by the beekeeper and biologists and an ecologist who was working with Tiff Nature Preserve at the time, and is now with the Buffalo Audubon Society. And so, the students designed a beehive — they called it "Elevator B" — and built it, and it worked

perfectly for a while. The beekeeper was able to move the bees from the existing hive to the student-designed beehive. The process was actually quite funny, it involved using a shopvac and sucking the bees out and capturing the queen and then blasting the bees back in the new hive. It actually worked fine. They starting building a comb, but after the winter the new beehive was not as warm as we thought it was going to be and the bees that we so carefully moved over actually died. The good news is that, after a lot of tweaking and figuring out what some of the issues were, the students and property manager built an additional layer in the beehive to maintain the thermal environment a little bit better and a new hive developed in there. This was built ten years ago and there are still bees in there right now. Another example is a project called Bat Cloud. (Fig. 5) I had built it for bats, but for a number of years the project had no bats in it. It got to a point where the site managers at Tiff Nature Preserve were thinking, well maybe it's time to take this project down because it's starting to need some touching up and because it was only intended to be a couple of years' temporary installation, and now it's been up here for five years. But as it turned out, a biologist from another university nearby, SUNY Fredonia, was doing some research looking at bat populations and actually did find bats flying in and out of this project. So now it's a strange situation because the installation was built to really just be up for a couple of years, so it's not in the best physical condition after ten years, but because of the fact that bats are in there, it can't be touched, even though it could use some repair. Yeah, misalignments happen all the time and then you sort of have to be attentive and fix things and remedy things if possible.

Figure 5. Bat Cloud winter



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RG: These are good examples of what environmental philosophers call “entanglements;” the way the lines between the human / animal divide have become more or less blurred,

generally towards beneficial ends. It aims to counteract problematic ideas like wilderness, the nineteenth century term for grasping nature as something completely exterior to human being. Today, you have an understanding that ecosystems pervade human spaces, that even a concrete sidewalk can have moss, grass, and insects. Your work dramatizes these ideas in very effective ways. I remember as a child we discovered a massive beehive hanging from the eaves of our roof and we had an exterminator take it down. We took it apart and learned that the beehive was composed of fiberglass insulation from the roof that the bees had been poaching. So, they actually made their natural/unnatural habitat. Of course, as the globe gets increasingly urbanized, we may have no choice but to consider these compromised conditions. In your bat habitats for Griffis Sculpture Park, you talk about how you could have purchased bat habitats that blend into the environment but yours intentionally stand out. (Fig. 6) You're very much conscious about the fact that these are artifices, that these are constructed environments. You make that a key element in your work.

Figure 6. Bat Tower



© Joyce Hwang

JH: I think that's almost a given for most architects. I can't imagine that any architect is thinking that what they are building is natural, even if what you're using are natural materials. But the question of constructing artifice as a form of habitat is certainly not new and it's hard to try to think otherwise because the world we're living in right now, a large part of the world is urbanized and the rate of urbanization is only happening faster and urbanization is one of the key causes of biodiversity loss and this is something that is urgent. We, as architects and humans, have to deal with this. So, I think that intentionally making a structure conspicuous and very markedly part of the designed environment is part of the agenda. I don't think it's helpful at all to think that only planting trees and including constructions that are not artificial, that that's the only way to make any difference. The fact is, what we really need to address is how to urbanize while increasing biodiversity.

Figure 7. To Middle Species with Love Site . Plan Collage 01



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RG: Is it fair to say that your clients are animals and insects while your audiences are humans? In the work you currently have up in Columbus you introduce what look like historical elements in your work. They remind me of Constructivist forms, I'm thinking Vladimir Tatlin. (Fig. 7) I wondered if that was intentional, and I wondered how you navigate the many audiences looking at your work, which includes architects seeing your work not just on site, but also in architectural journals.

JH: First, I think it is right to say that my clients, or the users, or the occupants or the stakeholders of the projects are animals and that the audiences are humans. But ultimately, humans are stakeholders as well. I think with every project it's quite different. For Exhibit Columbus, the audience is not just the people in Columbus because Columbus is a small city — there's around 50,000 people — it's an incredible town that has an incredible legacy of architecture. Any random person that you run into on the street knows a lot about Saarinen or architects from the twentieth century because of the legacy of architecture in Columbus and the Cummins Foundation Program. There's a particular local audience that's really in tune with architects, so one of the intentions of that particular program was that the installation somehow resonate in some way with the site. The sites are designed by specific architects, so in my case, our project was in Mill Race Park, which is a park that was designed by Michael Van Valkenburgh and the structures in that park were designed by Stanley Saitowitz. So, there's definitely a clear reference between some of the structures that I built and the observation tower on site, which is a concrete, almost Brutalist-looking tower. It's interesting that you mention the Constructivists but I didn't have that mind. In fact, the bat houses are modeled after a very conventional bat house typology which is the Rocketbox bat house. That's a type of bat house that has been particularly helpful for the endangered Indiana bat. So, I was looking at bat house typologies and trying to find a way to enhance them with other sorts of habitat conducive structures.

RG: I think somewhere you talk about your work as challenging the modern values of cleanliness, one could also add hygiene, the whole modern rhetoric of the need for spaces to have abundant light and air. When you think about your pieces also participating in the world of human architecture, do they suggest something about how architecture itself or

the design of buildings might move towards the creation of more ecosystem-rich urban environments?

JH: In terms of challenging ideas of cleanliness and hygiene, I think certainly one of the ways that my work challenges that paradigm is that a lot of the projects I've designed are considered to be sculptures or art work and belong in a sculpture park. And because of the fact that they are intended to be inhabited by animals, you do see a level of occupation that then defines what the project is. Unlike typical sculptures and artwork, the installations shouldn't be repaired and cleaned regularly, as cleaning regularly would be detrimental to the habitat. So, the Bat Tower in Griffis Sculpture Park is one where, when you go and look at it right now, there is actually bat shit everywhere, bat guano sitting around on the structure itself. Thinking about how built structures can be part of the ecosystem, part of the environment and don't necessarily need consistent maintenance and cleaning is something that interests me. I bought a vacant property in Buffalo recently and I'm going to be, hopefully in the near future, designing a house and studio for myself there. So, I'm thinking of integrating a lot of these ideas into that project, so then we'll really see how much I can withstand not cleaning things.

RG: Your work makes me think of François Roche's (R&Sie(n)) *I'm Lost in Paris* house where there is a codependence established between the user, the client, and the natural organisms. In the case of that particular house, it finds itself in the middle of a courtyard and is incredibly exposed because you have the windows of the adjoining apartment building looking onto it. The only way that the client can have any privacy, therefore, is to maintain this rich foliage that is composed of a specific species of fern that need to be fed a particular enzyme in each of the hundreds of watering flasks holding the plants. So, we get back to the idea of entanglements, the human, in order to get privacy – which is a very *human* need – has to enter into a relationship based on interdependencies with a non-human species. I wonder, because you mention designing a house, so we see the habitats giving animals something but is there a next step in your work to move towards a mutual relationship.

JH: I think that there already is a mutual relationship between humans and animals that we just have to recognize. One of the reasons that people are trying to attract bats more and more these days – which was not the case more than ten years ago when I first moved to Buffalo – the reason people are wanting to bring bats back is that they eat a lot of mosquitos. Informally, at a party I've heard people say, "Oh, I'm building some bat houses because I can't deal with these mosquitos anymore." So, I think there already is a co-dependency or mutual relationship to some extent. But in terms of the upcoming house project, I was thinking about those birds that build their nests with trash, or birds that build their nests with cigarette butts, and they found that cigarette butts are really useful in terms of keeping certain parasites away from nests, and some birds will even seek out cigarette butts to build their nests. Part of me was wondering if there are certain ways that animals building nests or animals building something for themselves would also be a way to start contributing to the larger home environment. If you had a wall that was filled with bird nests, and let's say that the birds all used cigarette butts, would that be a way to prevent parasites from growing in your wall. I don't know, I'm not projecting that specific scenario is going to happen, but I think there's always going to be some kind of mutual relationship regardless what happens.

Figure 8. Hugo Häring, Gut Garkau, Germany, 1923-1926.



Wikimedia Commons, seier + seier

RG: In thinking about historical example where architects have designed for animals or non-human species, one really interesting one is the cowshed at Gut Garkau near Lübeck, Germany by the architect Hugo Häring. (Fig. 8) It was designed for animals in a similar way as people were designing kitchens through understanding human behaviors or applying Taylorist models to production to streamline production lines. There is real attentiveness to the way that cows interact, the way they feed, the way they bully each other. So, one element that often gets highlighted is the way there are no sharp corners, all the corners are rounded, and that's because some of the older cows would push calves into corners, potentially injuring them. It's an interesting project because to me, it's always seemed as the degree zero of functionalism. It's of course ironic that the most functionalist building happens also not to be intended for humans, but for cows. In a way, there is something very similar in your process – you are also working with biologists and ecologists, you are trying to really understand the behaviors, the actions, the cycles that these animals engage in. I wondered if you could take us through your design process and tell us a little about how the forms of your project emerge.

JH: I actually started thinking about Temple Grandin's humane slaughter machine when you described the cowshed. In terms of my process, I think there's certainly a lot that starts with research, talking with biologists, and so on. But there's also a big part that starts with trying to distill spatial conditions from research. This is something I do with my students a lot where we will look at a particular animal or a particular species and we'll go through an exercise where we talk about this notion of *umwelt*, a term coined by Jakob von Uexküll to talk about the specific environment of species. Of course, the example he offers that is kind of known is the tick and the deer. Even though the tick and the deer are both in the forest, the tick's specific environment is the deer. The tick doesn't care about the forest while the deer cares about the forest. The thing that I always try to do first is, after doing a whole bunch

of research and talking to people and making observations, to really try to think about what the specific conditions are to make a set of spatial types or spatial conditions that I can start to work with. So, then I'll work on a process where I'll say, "ok, I am going to work with slotted spaces that are roughly $\frac{3}{4}$ of an inch thick and I'm going to work on surfaces that have ridging." That's a specific thing related to bats, bats climbing into spaces and the kinds of gaps that bats will occupy. So, I'll work with that as a kind of vocabulary, let's say, and then start building models, say physical models, Rhino models, or whatever, using these elements and bringing them together and thinking about that as spatial building blocks. And then I'll usually work through a lot of different iterations and bring the biologist back into the picture. One thing I found is, working with people who are not architects it's helpful for them to look at physical models. Often what's helpful is if I drag a big physical model with me, even if I'm going out for a coffee with a biologist, I'll put a physical model in my arm and say what do you think of this? So, it's a back and forth in that way. In a project like Exhibit Columbus it's slightly different. I started out with a typical bat house, I started out with the rocket box bat house which has already been something that's used, that's been understood to work for Indiana bats. It has a specific set of dimensions. So, I literally just took the dimensions that were provided from the off-the-shelf DIY bat houses and I used that as a starting point to then build off of.

RG: And do you put some of these models in the field? Are there ways to test them out? I guess you have done a number of bat houses, what have you learned from the various iterations?

Figure 9. Habitat Wall Prototype-Gallery



© Joyce Hwang

JH: Well for Bat Habitat Wall Cloud, for the first version, we made some prototypes and put them outside just to see what would happen. (Fig. 9) We weren't testing

necessarily for bat occupation but we were looking at temperature monitoring, things like that. So, I had a thermal camera that I was using to take photos of the bat house. One thing we were also trying to look at was how well heat would be retained inside the bat house pods. We were doing experiments like heating up gel packs to a degree where they would be thermally equivalent to a warm blooded creature and we were shoving them into the pods to see how long the heat would stay. Looking at thermal environments is something we'll experiment with too.

RG: One could argue that architects have no real center to their discipline, they don't necessarily have a real source of expertise. They don't build buildings, they draw drawings that in turn prescribe buildings to be built by others. And that might be an advantage to the field because, if architects are experts at anything, it is at bringing multiple disciplines in conversation with each other. You've talked a lot about your collaborations with biologists and I'm wondering if you think there might be a model there in your relationships with biologists that could be expanded?

JH: In earlier projects, I was collaborating with biologists and ecologists and asking for their advice as consultants, in a way. My later projects like Life Support, for example, which was completed in 2019, was a collaboration with an ecologist in Australia, Darren LeRoux, but also a data visualization designer, Mitchell Whitelaw, who teaches in the School of Arts and Design in Australian National University. Interestingly, he and I were at the same conference together with Darren who was presenting his research on very large trees and their ecological benefit. And it was Mitchell who thought that the three of us could actually work together. At that point I wasn't even thinking, "oh, I'm going to reach out to this data visualization guy and try to collaborate" but he saw the potential in it. So, the three of us did work collectively on a project in Australia. I was doing most of the architectural design and collaborating with a structural engineer. The project was basically to use a four-hundred-year-old yellowbox eucalyptus tree that was slated to be removed from a residential neighborhood in Canberra. And normally when trees are taken down from residential neighborhoods in Australia, which is quite common apparently because of the heaviness of the branches and the fact that they frequently drop and damage property. But it's a problem to just cut it down and make it into firewood because large, old trees inherently have a lot of ecological value. The knot holes, peeling bark, and everything about the tree itself provides rich ecological habitats. And so, I worked with these two collaborators in Australia, first to go through the process of figuring out how we would take down the tree and cut it in as few pieces as possible so that it could be used in a sculptural design project. And once the tree was taken down, we had to develop a digital model of the existing tree parts, to even begin to work with it. There was a lot of work with the data visualization designer to use photogrammetry to try to capture the form of the tree, and later on he became very instrumental in putting camera traps on the installation documenting species that were coming to the area around the project.

RG: Were the cameras accessible to watch online?

JH: Yes, Mitchell, the digital designer made a website called Molonglo Life and that website hosted a lot of videos and photos that were taken from the camera traps. And the hope was that people would start to identify species almost as a form of citizen science. In more recent collaboration for our Exhibit Columbus Project, I collaborated with biologists from the Indiana Department of Natural Resources, and have also been working with two musicians—Shawn Chiki and Zach Williams—who have been

experimenting with bat sounds. We installed ultrasonic bat detectors that are recording bat sounds in the area. We've been collecting these sounds and giving them to musicians to use as source material for making compositions. It's actually really cool, this is the thing I'm really excited about right now. These musicians are basically exploring and mixing bat sounds and it almost sounds like Berlin techno. Even for the opening of Exhibit Columbus we had a bat concert where musicians were taking the bat sounds and playing around with them and making soundtracks with them. So, I think there are certainly collaborations in trying to realize a project but there is also collaboration in what a project can produce, what the afterlife of the experience of the project can be.

RG: My last question goes back to the idea of translating back to human users from animal users. Bats have very specific needs. Human needs, however, are a little bit more difficult to pin down. There are all sorts of needs that are not material needs that humans have. But when focusing on animals and their narrower material needs, I'm wondering if your research has given you new perspective on the larger set of needs that humans have. While there are problems with translating certain lessons from the animal kingdom to humans, I wonder if there are also opportunities in considering what humans can learn from ways that animals respond to built environments.

JH: I don't think I've been thinking along those lines of how do we take lessons from what we've learned about animals as inhabitants or stakeholders in the world and how we translate those as humans in the world. I don't think about it so explicitly as a translation, but I think that there is a lot about what we learn from the way animals occupy the world that affect the way humans occupy the world and should become part of our ways of understanding things. So, for example, the fact that we understand what a setback is based on sunlight. That's something that feels almost normal now. We understand that if a building is tall enough, there is a need for sunlight to come in. What we don't think of are setbacks for things like squirrels jumping. A squirrel jumping setback should be around 10 feet. So, if you don't want a squirrel to jump into your house from a tree, you better set your house 10 feet away from a tree. So, I think there are certain things about animal behavior that could work their way into the way we think about our designed environments. That's something I think about a lot when I think about both animal space and human space.

AUTHOR

RALPH GHOCHÉ

Ralph Ghoche is a historian of architecture and urbanism and Assistant Professor in the Department of Architecture at Barnard College, Columbia University. His current research looks at the territorial interventions of the Catholic Church in Colonial Algeria in the 19th century. He has taught on a range of themes related to nature and the environment, including a lecture class on architectural responses to the changing perceptions of nature from the Enlightenment to the present, and a seminar on the biological metaphor in architecture.